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PIEZOELECTRIC ACTUATOR MANUFACTURING METHOD, PIEZOELECTRIC ACTUATOR, LIQUID SPRAY HEAD AND LIQUID SPRAY DEVICE

[Atsuden akuchiyueeta no seizo hoho, atsuden akuchiyueeta, ekitai funsha heddo oyobi ekitai funsha sochi]

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Claims /2*

1. A manufacturing method for a piezoelectric actuator provided with a vibration plate that includes an insulation film and a bottom electrode formed on said insulation film, a piezoelectric layer formed on said vibration plate, and a top electrode formed on said piezoelectric layer,

which is a piezoelectric actuator manufacturing method that includes:

a process to form an insulation film on a substrate,

a process to form a bottom electrode on the aforementioned insulation film,

a process to form a piezoelectric film on the aforementioned bottom electrode,

a process to form a first conducting film on the aforementioned piezoelectric film,

a process to form a conducting layer by implanting ions through the aforementioned first conducting film at least at the boundary of the aforementioned piezoelectric film and the first conducting film, and to constitute a top electrode formation film provided with said first conducting film and the conducting layer,

and a process to pattern the aforementioned piezoelectric film and the top electrode formation film, and to form a piezoelectric layer and a top electrode.

2. The piezoelectric actuator manufacturing method described in Claim 1 wherein the process to form the aforementioned first conducting film includes a process to form an adhesion film on the aforementioned piezoelectric film, and a process to form a second conducting film on said adhesion film.

3. The piezoelectric actuator manufacturing method described in Claim 1 or Claim 2 wherein the aforementioned ions are additionally implanted in the aforementioned first conducting film side of the aforementioned piezoelectric film.

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* [Numbers in right margin indicate pagination of the original text.]

4. A piezoelectric actuator manufactured with the piezoelectric actuator manufacturing method described in any one of Claims 1-3.

5. A liquid spray head provided with:

the piezoelectric actuator described in Claim 4,

a pressure generating chamber in which the internal volume changes according to mechanical displacement of the aforementioned piezoelectric actuator,

and a discharge opening that discharges liquid droplets that is connected to the aforementioned pressure generating chamber.

6. A liquid spray device provided with the liquid spray head described in Claim 5,

and a drive apparatus that drives the aforementioned liquid spray head.

Detailed explanation of the invention

Technical field

[0001]

The present invention relates to a manufacturing method for a piezoelectric actuator that utilizes the piezoelectric effect of a piezoelectric film, a piezoelectric actuator, a liquid spray head and a liquid spray device.

Prior art

[0002]

Previously, there is the inkjet recording head, for example, as an example of a liquid spray head. With an inkjet recording head, a piezoelectric actuator that utilizes the piezoelectric effect of a piezoelectric film is used as the driving source for ink discharge by the printer. The piezoelectric actuator is constituted

with a vibration plate that constitutes a part of a pressure generating chamber connected with a nozzle opening (discharge opening) that discharges liquid droplets (ink droplets), and a piezoelectric element formed on the vibration plate and that has a bottom electrode, a piezoelectric layer, and a top electrode. With such an inkjet recording head, various improvements have been made for the purpose of obtaining stable ink droplet discharge characteristics and to improve reliability.

[0003]

In such an inkjet recording head, for example, there is a bonding substrate that is bonded to the /3
piezoelectric film side of a channel formation substrate provided with at least two rows of pressure generating chambers that are connected with a nozzle opening as well as being demarcated with multiple partitions, and on which a drive circuit to drive the piezoelectric layer is mounted. A through-hole is also furnished through said bonding substrate in the thickness orientation in the portion of the bonding substrate corresponding to the space between the aforementioned pressure generating chamber rows. A lead wire from each of the piezoelectric layers extends to the portion corresponding to the aforementioned through-hole, and said lead wires and the aforementioned drive circuit are electrically connected with conductive wire extended through the aforementioned through-hole. Thus the surface area of the through-hole is kept small, and miniaturization is achieved. (Refer to Patent Citation 1).

[0004]

When the conventional inkjet recording head described above is manufactured, the method below is usually used. In short, a silicon monocrystalline substrate wafer which will become the channel formation substrate is thermally oxidized in a diffusion furnace at about 1100°C to form an elastic film made of silicon dioxide. Next, after a bottom electrode formation film is formed over the entire elastic film using

sputtering, the bottom electrode formation film is patterned to form the bottom electrode. Next, after a piezoelectric film is formed with a sol-gel method on the elastic film where the bottom electrode was formed, the piezoelectric film is fired and crystallized at a temperature of around 600-1000°C in air or an oxygen atmosphere. Next, a film of Pt, Ir or the like is formed using sputtering to form a top electrode formation film, the top electrode formation film and the piezoelectric film are patterned and the top electrode and a piezoelectric layer are formed, other desired processes are performed, and an inkjet recording head is manufactured.

Patent Citation 1

Japanese Kokai Patent Application No. 2003-246065.

Disclosure of the invention

Problems to be solved by the invention

[0005]

However, with the conventional inkjet recording head described above, adhesion between the piezoelectric layer and the top electrode is insufficient, and there is the risk of problems occurring, such as the top electrode easily separating, and there is the possibility of the yield or reliability decreasing. So when a backing metal (adhesion film) such as Ti, which has satisfactory adhesion with the piezoelectric layer, is used as the top electrode, the backing metal oxidizes, and it is difficult to obtain sufficient piezoelectric characteristics.

[0006]

With this structure, too, a low dielectric layer easily occurs between the piezoelectric layer and the top electrode, and there is the risk that sufficient piezoelectric characteristics will not be obtained. So in order to prevent a low dielectric layer from occurring between the piezoelectric layer and the top electrical [layer], performing a reverse sputtering process prior to forming the top electrode formation film using sputtering is conceivable, but when a reverse sputtering process is performed, the surface composition of the piezoelectric layer changes, and there is the risk of piezoelectric characteristics being reduced.

[0007]

The present invention was devised in consideration of such a situation, with the objective of providing a manufacturing method for a piezoelectric actuator that has outstanding piezoelectric characteristics, and with which adhesion between the piezoelectric layer and the top electrodes is improved.

[0008]

An objective of the present invention is also to provide a piezoelectric actuator that has outstanding piezoelectric characteristics, and with which adhesion between the piezoelectric layer and the top electrodes is improved

Means to solve the problems

[0009]

The present invention to accomplish the above objectives is a manufacturing method for a piezoelectric actuator provided with a vibration plate that includes an insulation film and a bottom electrode formed on said insulation film, a piezoelectric layer formed on said vibration plate, and a top electrode formed on

said piezoelectric layer, and provides a piezoelectric actuator manufacturing process that includes: a process to form an insulation film on a substrate, a process to form a bottom electrode on the aforementioned insulation film, a process to form a piezoelectric film on the aforementioned bottom electrode, a process to form a first conducting film on the aforementioned piezoelectric film, a process to implant ions through the aforementioned first conducting film at least at the boundary of the aforementioned piezoelectric film and the first conducting film to form a conducting layer and to constitute a top electrode film provided with said first conducting film and a conducting layer, and a process to pattern the aforementioned piezoelectric film and the aforementioned top electrode /4
film to form a piezoelectric layer and a top electrode.

[0010]

With a piezoelectric actuator manufacturing method that includes these processes, a conducting film is formed by implanting ions through a first conducting film formed on the aforementioned piezoelectric film at least at the boundary of said piezoelectric film and the first conducting film, and a top electrode formation film provided with said first conducting film and a conducting layer is constituted, so said top electrode formation film will not separate from the piezoelectric film. In addition, no dielectric layer, which is one cause of the piezoelectric characteristics of said piezoelectric layer being reduced, is formed at the boundary of the piezoelectric layer and the top electrode. Therefore, outstanding piezoelectric characteristics can be provided.

[0011]

With the piezoelectric actuator manufacturing method pertaining to the present invention, too, the process to form the aforementioned first conducting film can include a process to form an adhesion film

on the aforementioned piezoelectric film, and a process to form a second conductive film on said adhesion film. By so doing, adhesion between the aforementioned top electrode formation film and the piezoelectric film can be improved. Moreover, in this case, the boundary between the piezoelectric film and the first conducting film is the boundary between the piezoelectric film and the adhesion film.

[0012]

With the piezoelectric actuator manufacturing method pertaining to the present invention, as well, the aforementioned ions can additionally be implanted into the aforementioned first conducting film side of the aforementioned piezoelectric film. With this process, the layer on the first conducting film side of the piezoelectric film, including the aforementioned boundary, will also be a conducting layer.

[0013]

The present invention also provides a piezoelectric actuator manufactured with the piezoelectric actuator manufacturing method pertaining to the present invention. The actuator can be provided both with outstanding adhesion between the piezoelectric layer and the top electrode, and with outstanding piezoelectric characteristics.

[0014]

The present invention also provides a liquid spray head provided with a piezoelectric actuator pertaining to the present invention, a pressure generating chamber in which the internal volume changes according to mechanical displacement of the aforementioned piezoelectric actuator, and a discharge opening that discharges liquid droplets connected to the aforementioned pressure generating chamber.

[0015]

The present invention provides, in addition, a liquid spray device provided with a liquid spray head pertaining to the present invention, and a drive apparatus that drives the aforementioned liquid spray head.

Effect of the invention

[0016]

With the piezoelectric actuator manufacturing method pertaining to the present invention, a conducting layer is formed by implanting ions through a first conducting film formed on the piezoelectric film at least at the boundary of said piezoelectric film and the first conducting film, and a top electrode formation film provided with said first conducting film and a conducting layer is constituted, so the top electrode that is formed later will not separate from the piezoelectric film. The result is that adhesion between the piezoelectric layer and the top electrode can be improved. And no dielectric layer, [the formation of] which is one cause of the piezoelectric characteristics of said piezoelectric layer being reduced, is formed at the boundary of the piezoelectric layer and the top electrode. The result is that yield can be improved, and a piezoelectric actuator provided with outstanding reliability can be manufactured.

Optimum embodiments for implementing the invention

[0017]

Next, a piezoelectric actuator and the manufacturing method therefor pertaining to a preferred embodiment of the present invention are explained with reference to the figures. The embodiments described below are examples for explaining the present invention and the present invention is not limited only to these embodiments. The present invention can be implemented in a variety of forms as long as they do not deviate from its essential points.

[0018]

Figure 1 is an exploded oblique view of a liquid spray head provided with a piezoelectric actuator pertaining to a preferred embodiment of the present invention. Figure 2 is a plan view showing a part of the liquid spray head shown in Figure 1 near the piezoelectric actuator. Figures 3-8 are cross sections /5
showing a part of the manufacturing process for the liquid spray head shown in Figure 1. Figure 9 is an oblique view showing an overview of an inkjet recording device in which the liquid spray head shown in Figure 1 is mounted.

[0019]

As shown in Figures 1-8, in the liquid spray head pertaining to the present invention, piezoelectric actuators 100 are arranged in areas corresponding to pressure generating chambers 30 of channel formation substrate 10 in which multiple pressure generating chambers 30 are formed. With this embodiment, a (110) plane oriented silicon monocrystalline substrate is used as channel formation substrate 10. 1-2 μm thick elastic film (insulation film) 25 composed of SiO_2 film 11 and ZrO_2 film 12 is formed on one side of channel formation substrate 10. The other side of channel formation substrate 10 is the aperture plane.

[0020]

Multiple pressure generating chambers 30 formed by anisotropic etching of the silicon monocrystalline substrate are formed in the aforementioned aperture plane of channel formation substrate 10. Outside of them, in the length orientation, they are connected to reservoir part 51 of bonding plate 24, described below, and are connected through an ink supply path 53 to connection part 52 that constitutes a part of a

reservoir which is a common ink chamber for each pressure generating chamber 30. Moreover, on the aforementioned aperture plane of channel formation substrate 10, SiO_2 film 33 (refer to Figure 8), provided with a function as a protective film having resistance to the ink stored in pressure generating chambers 30, is formed.

[0021]

In addition, on the aperture plane side of channel formation substrate 10, nozzle plate 36, through which nozzle openings 35 that connect on the opposite side from ink supply paths 53 of pressure generating chambers 30 pass, is affixed with a bonding agent, thermal adhesion film or the like. Nozzle plate 36 covers one entire surface of channel formation substrate 10 on one side, and also serves the role of a reinforcing plate that protects the silicon monocrystalline substrate from shock and external force. In this case, because the deformation in channel formation substrate 10 and nozzle plate 36 caused by heat is approximately the same, they can easily be bonded using a thermosetting bonding agent.

[0022]

Here, the size of pressure generating chambers 30 that provide ink droplet discharge pressure to the ink, and the size of nozzle openings 35 that discharge ink droplets are optimized according to the quantity of ink droplets to be discharged, the discharge speed, and the discharge frequency. For example, to record 360 ink droplets per inch, nozzle openings 35 must be formed precisely with a diameter of several 10s μm.

[0023]

On the other hand, on elastic film 25 formed on the opposite side of channel formation substrate 10 from the aforementioned aperture plane, bottom electrode 13, piezoelectric layer 18, and top electrode 19

are formed on the area where pressure generating chambers 30 are formed. Bottom electrode 13 constitutes a vibration plate along with elastic film 25. Top electrode 19 is constituted with first conducting film 15 and conducting layer 16. (Refer to Figures 6-8). Piezoelectric actuator 100 is constituted by the portion that includes piezoelectric layer 18 and top electrode 19. (Refer to Figure 1 and Figure 2).

[0024]

On top electrode 19, a protective film 20 is formed so that piezoelectric flayer 18 will not be degraded by moisture from the outside. Top electrode 19 is electrically connected with wire 22 through contact hole 21 formed in protective film 20. (Refer to Figure 7 and Figure 8).

[0025]

Moreover, with this embodiment, bottom electrode 13 is a common electrode for piezoelectric actuator 100, and top electrode 19 is separate electrodes for piezoelectric actuator 100, but it could also be the reverse for the sake of drive circuitry or wiring. In either case, a piezoelectric actuator 100 is formed for each pressure generating chamber 30.

[0026]

Bonding plate 24 is placed on the opposite side of channel formation substrate 10 from where nozzle plate 36 is placed (the top surface in Figure 1). Reservoir part 51 that constitutes a part of the reservoir is /6
formed on bonding plate 24. Reservoir part 51, in this embodiment, is formed over the width orientation of pressure generating chamber 30 through bonding plate 24 in the thickness orientation, and is connected

with connection part 52 of channel formation substrate 10 to constitute a reservoir that is a common ink chamber for each pressure generating chamber 30.

[0027]

In the area of bonding plate 24 facing piezoelectric actuator 100, a piezoelectric actuator holding part 54, that ensures that movement of piezoelectric actuator 100 is not hindered, is provided corresponding to each pressure generating chamber 30. Moreover, this space may be sealed or not sealed.

[0028]

With this embodiment, piezoelectric actuator holding part 54 is furnished for each row of piezoelectric actuators 100, but piezoelectric actuator holding part 54 could also be furnished independently for each piezoelectric actuator 100. For bonding plate 24, it is preferable that a material with approximately the same coefficient of thermal expansion as channel formation substrate 10, for example, glass or a ceramic material, be used. With this embodiment, it was formed using a silicon monocrystalline substrate, the same material as channel formation substrate 10.

[0029]

In addition, approximately in the center part of bonding plate 24, that is, the area facing the space between the row of pressure generating chambers 30, through-hole 55 is furnished through bonding plate 24 in the thickness orientation. On both sides of through-hole 55 of bonding plate 24, that is, in a portion corresponding to each row of pressure generating chambers 30, a drive circuit 110, such as a circuit board or a semiconductor integrated circuit (IC), for example, is mounted to drive each piezoelectric actuator 100. For example, with this embodiment, individual drive circuits 110 mounted on both sides of

through-hole 55 are to drive the piezoelectric actuators 100 furnished in the regions facing the respective drive circuits 110.

[0030]

The liquid spray head pertaining to this embodiment takes in ink through an ink introduction opening connected to an external ink supply means, which is not shown. After the inside is filled with ink from the reservoir to nozzle opening 35, voltage is applied between respective bottom electrode 13 and top electrode 19 corresponding to pressure generating chambers 30, the internal volume of pressure generating chambers 30 is changed by the vibration plate composed of bottom electrode 13 and elastic film 25 deforming by flexing due to mechanical displacement produced by the piezoelectric effect of piezoelectric layer 18, the pressure in each pressure generating chamber 30 is increased, and ink droplets are discharged from nozzle opening 35.

[0031]

This liquid spray head constitutes part of a recording head unit provided with an ink path that connects with an ink cartridge or the like and is mounted in an inkjet recording head.

[0032]

In concrete terms, as shown in Figure 9, recording head units 1A and 1B that have a liquid spray head are furnished with cartridges 2A and 2B that constitute an ink supply means and are detachable, and carriage 3 in which recording head units 1A and 1B are mounted is furnished to be able to move in the axial orientation on carriage shaft 5 attached to device base unit 4. Recording head units 1A and 1B discharge a black ink composition and a color ink composition, respectively, for example. Carriage 3 in

which recording head units 1A and 1B are mounted is moved along carriage shaft 5 by the drive force of drive motor 6 being transmitted to carriage 3 through multiple gears and timing belt 7. At the same time, platen 8 is provided along carriage shaft 5 in device base unit 4, and recording sheet S, which is a recording medium, such as paper supplied with paper feed rollers, which are not shown, is conveyed on platen 8.

[0033]

Next, the manufacturing process for the liquid spray head provided with the piezoelectric actuator /7 pertaining to this embodiment is explained with reference to the figures.

[0034]

First, SiO_2 film 11 is formed using thermal oxidation, for example, on the silicon monocrystalline substrate which will be channel formation substrate 10, as in the process shown in Figure 3. Next, ZrO_2 film 12 is formed on SiO_2 film 11. In this embodiment, SiO_2 film 11 and ZrO_2 film 12 become elastic film (insulation film) 25. Next, a bottom electrode formation film is formed on elastic film 25 using sputtering, and this is patterned to the desired shape to form bottom electrode 13. As the material constituting bottom electrode 13, a desired conductive material, such as Ti, Ir or Pt, for example, can be used.

[0035]

Next, with the process shown in Figure 4, a piezoelectric precursor film is formed at a predetermined thickness on channel formation substrate 10 where bottom electrode 13 is formed using a sol-gel method. Next, channel formation substrate 10 on which the piezoelectric precursor film is formed is fired and

crystallized at a temperature of about 600°C or more in the air or an oxygen atmosphere. By being fired at such a high temperature, piezoelectric film 14 is sufficiently crystallized.

[0036]

Here, it is preferable that the crystals of piezoelectric film 14 be oriented. For this purpose, in this embodiment, what is called a sol in which a metal organic substance is dissolved and dispersed in a catalyst, for example, is applied and dried to gel it, a piezoelectric precursor film that has no crystallinity is formed, and piezoelectric film 14, which is crystalline, composed of a metal oxide, is obtained by additionally firing the piezoelectric precursor film at high temperature. As the material for piezoelectric film 14, a material such as lead zirconium titanate, for example, can be used to advantage. The formation method for piezoelectric film 14 is not specifically limited, and it could be formed using sputtering, for example. In addition, a method could also be used wherein crystals are grown at low temperature with high-pressure treatment in an alkali aqueous solution after a lead zirconium titanate piezoelectric precursor film is formed using a sol-gel method or sputtering.

[0037]

In piezoelectric film 14 that is formed in this way, the crystals have preferred orientation, unlike a bulk piezoelectric, and in this embodiment, the crystals in piezoelectric film 14 are formed in a columnar form. Preferred orientation refers to a state in which specific crystal faces are pointed in approximately a constant direction rather than the direction of crystal orientation being random. And a thin film in which crystals are columnar refers to a state in which approximately round columnar crystals are amassed across the plane orientation with their center axes basically consistent in the thickness orientation to form a thin

film. Of course, it could also be a thin film formed with granular crystals in a preferred orientation. In this embodiment, the thickness of piezoelectric film 14 is 0.2-5 μm.

[0038]

Next, first conducting film 15 is formed on piezoelectric film 14 at a thickness of around 10-200 nm using sputtering. As the material constituting first conducting film 15, the desire conductive material, such as Ir, IrO, Pt, W, Ta or Mo, for example, can be used. In this process, reverse sputtering can also be performed as pre-treatment.

[0039]

Next, in the process shown in Figure 5, ions are implanted through first conducting film 15 obtained with the process shown in Figure 4, at least at the boundary of first conducting film 15 and piezoelectric film 14. In this embodiment, ions were also implanted into the top layer of piezoelectric film 14, that is, on the first conducting film 15 side of piezoelectric film 14. Ions were also implanted into first conducting film 15. In this embodiment, too, ion implantation (ion injection) was performed with Al ions, with implantation voltage of 300 Kev, and implantation amount (dose): around 1×10^{19}-1×10^{21} / cm^2. The implanted ion species could be, for example, Ti, Ir, Pt, Pd, Mo or W. The area where the ions are implanted becomes conducting layer 16. Next, channel formation substrate 10 into which ions are implanted undergoes heat treatment for around 20 minutes at a temperature of around 300-400°C, for example, and conducting layer 16 is stabilized. Top electrode formation film 17 composed of first conducting film 15 and conducting layer 16 is constituted in this way.

[0040]

Conducting layer 16 is formed by implanting (injecting) ions at least at the boundary between first conducting film 15 and piezoelectric film 14 in this way, and top electrode formation film 17 is formed along with first conducting film 15, so top electrode formation film 17 will not separate from piezoelectric film 14, with the result that adhesion between piezoelectric layer 18 and top electrode 19 that are formed later can be improved.

[0041]

Next, with the process shown in Figure 6, piezoelectric film 14 and top electrode formation film 17 are patterned using photolithography, and piezoelectric layer 18 and top electrode 19 are formed. Piezoelectric actuator 100 composed of a vibration plate, which is composed of elastic film 25 and bottom electrode 13, piezoelectric layer 18, and top electrode 19 is formed in this way.

[0042]

Next, with the process shown in Figure 7, protective film 20 composed of an Al_2O_3 film is formed on channel formations substrate 10 on which piezoelectric actuator 100 is formed. Next, contact hole 20 is made in the part of protective film 20 to bond with top electrode 19, and after a wire formation film is formed on protective film 20, the wire formation film is patterned, and wire 22 that is electrically connected with top electrode 19 is formed through contact hole 21. As the material constituting wire 22, Al/TiW or Au/NiCr, for example, can be used to advantage.

[0043]

Next, with the process shown in Figure 8, bonding plate 24 is bonded to channel formation substrate 10 obtained with the process shown in Figure 7. Next the side of channel formation substrate 10 on the opposite side from where bonding plate 24 is bonded is selectively etched off, and pressure generating chambers 30 are formed. Next, SiO_2 film 33, which is resistant to the ink stored in pressure generating chambers 30, is formed at a thickness of about 0.1 μm using plasma CVD on the side of channel formation substrate 10 where pressure generating chambers 30 are formed. After this, nozzle plate 36, through which nozzle openings 35 pass, is bonded to the side of channel formation substrate 10 on the opposite side from where bonding plate 24 is bonded, other desired processing is performed, and the liquid spray head shown in Figure 1 is completed.

[0044]

In this embodiment, a case in which first conducting film 15 was formed on piezoelectric film 14 with the process shown in Figure 4 was explained, but is not limited to this. For example, as shown in Figure 10, adhesion film 26 that is conductive could be formed at a thickness of around 0.1-10 nm, for example, on piezoelectric film 14, and a second conducting film 27 could be formed at a thickness of around 10-200 nm, for example, on adhesion film 26. In this case, the material constituting adhesion film 26 is not specifically limited if it can improve adhesion between piezoelectric film 14 and second conducting film 27 and can be used as wiring, but, for example, Ti, Cr, TiW, TiN or NiCr, can be used to advantage. As second conducting film 27, the same materials as first conducting film 15 can be used to advantage.

[0045]

When the process shown in Figure 10 is performed, next, as shown in Figure 11, for example, a process to implant ions through adhesion film 26 and second conducting film 27 at least at the boundary between adhesion film 26 and piezoelectric film 14 can be performed. In this case, too, ions can also be implanted in the top layer of piezoelectric film 14, that is, the adhesion film 26 side of piezoelectric film 14, for example. Ions can also be implanted into adhesion film 26 and second conducting film 27. The area where the ions are implanted becomes conducting layer 16 the same as in the embodiment described above. Next, conducting layer 16 is stabilized the same way as described above, and top electrode formation film 17 composed of second conducting film 27, adhesion film 26 and conducting layer 16 is constituted.

[0046]

In this embodiment, too, a case in which elastic film (insulation film) 25 with a two-layer structure of SiO_2 film 11 and ZrO_2 film 12 is formed was explained, but is not limited to this. If elastic film 25 has an insulating function and the function of the piezoelectric actuator is not diminished, the formation material is not specifically limited, and a one-layer structure, or a three-layer structure, or more [than three] can be determined as needed.

[0047] /9

In this embodiment, as well, ions for forming conducting layer 16 were implanted, and for these ions, in addition to one species of ions, for example, Ir, Pt, W, Ta or Mo, being implanted as described above, two species of ions such as Mo/Si, W/Si, Ti/N or Ti/W could also be implanted. In addition, the first ions could be implanted at the desired concentration in the bottom layer portion of conducting layer 16, and the second ions could be implanted at a higher concentration than the first ions in the top layer (surface). In

this case, the first ions and the second ions could be different ions or the same ions. The ion implantation (injection) conditions are also not limited to the conditions described above and can be determined as desired. The ion implantation conditions, e.g., the amount of ions implanted into first conducting film 15, second conducting film 27 and adhesion film 26, or the implantation voltage can also be determined at will.

[0048]

In this embodiment, in addition, a case in which SiO_2 film 33 was formed as a protective film that is resistant to the ink stored in pressure generating chamber 30 was explained, but is not limited to this. For example, a SiN_x film, a TaO_x film or other formation material can be selected. It can also be a multilayer structure composed of different materials.

[0049]

With this embodiment, application not only to an actuator mounted as a liquid discharge means in a liquid spray head (inkjet recording head), but to an actuator device mounted in any device is possible. For example, the actuator device, in addition to the head described above, can be applied to a sensor or the like. In this embodiment, too, an inkjet recording head that discharges ink was explained as an example of a liquid spray head, but the present invention pertains broadly to liquid spray heads or liquid spray devices in general. Liquid spray heads include, for example, recording heads used for image recording devices such as printers, coloring material spray heads used to manufacture color filters such as for liquid crystal displays, electrode material spray head used for electrode formation for organic El displays, FED (surface emitting display), etc., and biological organic substance spray heads used for biochip manufacture.

Brief description of the figures

[0050]

Figure 1 is an exploded oblique view of a liquid spray head provided with piezoelectric actuators pertaining to a preferred embodiment of the present invention.

Figure 2 is a plan view showing part of the liquid spray head shown in Figure 1near the piezoelectric actuators.

Figure 3 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 4 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 5 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 6 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 7 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 8 is a cross section showing a part of the manufacturing process for the liquid spray head shown in Figure 1.

Figure 9 is an oblique view showing an overview of an inkjet recording device in which the liquid spray head shown in Figure 1 is mounted.

Figure 10 is a cross section showing a part of the manufacturing process pertaining to another embodiment of the present invention.

Figure 11 is a cross section showing a part of the manufacturing process pertaining to another embodiment of the present invention.

Explanation of symbols

[0051]

10 Channel formation substrate, 11 SiO_2 film, 12 ZrO_2 film, 13 Bottom electrode, 14 Piezoelectric film, 15 First conducting film, 16 Conducting layer, 17 Top electrode formation film, 18 Piezoelectric layer, 19 Top electrode, 25 Elastic film, 30 Pressure generating chamber, 100 Piezoelectric actuator

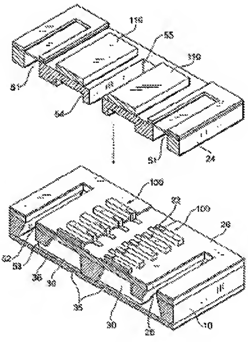

Figure 1

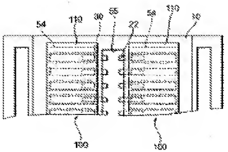

Figure 2

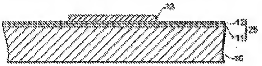

Figure 3

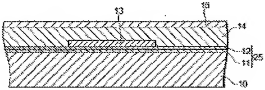

Figure 4

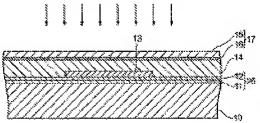

Figure 5

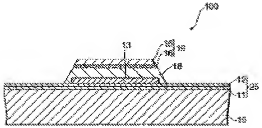

Figure 6

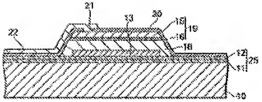

Figure 7

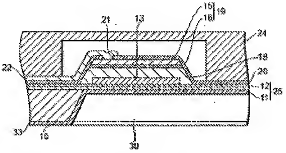

Figure 8

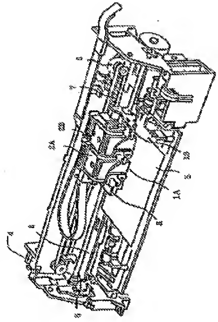

Figure 9

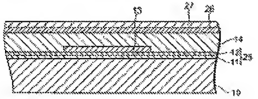

Figure 10

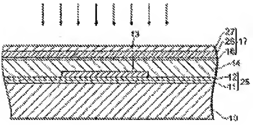

Figure 11